PATENT SPECIFICATION

DRAWINGS ATTACHED

1,059,983

1,059,983

Date of Application and filing Complete Specification: April 8, 1964.
No. 14603/64.
Application made in United States of America (No. 273398) on April 16, 1963.
Complete Specification Published: Feb. 22, 1967.

Index at acceptance:—**D2** A(7B4, 7B14, 1B15); **B5** N(17Y, 22Y, 35X, 35Y, 55Y, 71X, 191, 227, 250, 253X, 298X, 300X, 301X, 303X, 344, 345, 348, 349, 353, 354, 554, 557, 565, 567, 574, 577, 625, 626, 627, 638, 641, 659, 663, 665, 715, 765, 774, 792, 800); **D1** K(223, 34Y, 340, 379, 421, 430, 454, 465, 474, 475, 480, 55Y, 557, 558, 563, 565, 566, 577, 570, 68Y, 687, 688, 739, 76Y, 764)

Int. Cl.:—**D 21 f//B 32 b, D 03 d**

COMPLETE SPECIFICATION

Papermakers Wet Felt, Method and Apparatus for Dewatering Wet Web Using Such Felt

We, HUYCK CORPORATION, a corporation organised under the laws of the State of New York, United States, of Washington Street, Rensselaer, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described, in and by the following statement:—

The present invention relates to papermakers' felts and in particular to papermakers' wet felts, that is, felts which are used at the wet end of the machine as distinguished from dryer felts which are utilized to convey paper and similar felted cellulosic products over a heated dryer drum or drums. While certain aspects of the present invention are of value in connection with any of the various types of felts which are used at the wet end of a papermaking machine, the invention affords particular advantages in connection with those wet felts which are used to convey a very moist web of paper or the like through the press section of the papermaking machine. The press section comprises a press or a series of presses in which water is removed from the paper by mechanical pressure which is effective to transfer the water from the paper to or through the press felt.

The word "paper" will be used in a generic sense in this specification, and it is intended to include any of the products customarily referred to as paper as well as paperboard, cardboard, lap pulp and the like. All such products usually consist of felted cellulosic fibers with or without additional materials such as filling, sizing and the like.

In a papermaking machine of the Fourdrinier type a suspension of fibers in water with such other papermaking materials as may be present is caused to flow onto a travelling screen and a considerable portion of the water is caused to flow through the screen by the combined effects of gravity, table rolls, suction boxes, and the like, so that the fibers form a continuous felted web which is deposited upon the travelling screen. The continuous web as formed on the screen contains a large quantity of water and has very little strength. In this condition the web is removed from the travelling screen and is transferred either directly or indirectly as by a pick-up felt, to the press felt or the first press felt in the press section of the papermaking machine. When a series of presses is used it is usually the the practice to provide a separate press felt for each press.

In the past press felts usually have been absorbent woven and napped fabrics which are relatively resilient or compressible throughout their thicknesses. They have been made wholly or in part from wool fibers, although in some instances they have been made wholly from synthetic fibers such as polyamides (nylon) and polyesters ("Dacron"), "Dacron" is a Registered Trade Mark. Press felts of the type just described have been used to conduct the paper through the nip between the rolls of the press or presses. In any sort of press the thicknesses of the paper and of the compressible felt are progressively reduced as a result of increasing compression as the paper and felt progress into the nip. When they reach the point of minimum clearance in the nip the paper will contain a substantially smaller quantity of water than it did when it entered the nip as a result of transfer of water therefrom to the press felt. However,

as the paper and press felt progress beyond the point of maximum compression in the nip and both the paper and the felt progressively expand toward their original thicknesses, a significant period of time exists during which water may flow by capillarity from the felt into the paper. Separating the paper from the felt as quickly as possible after the system passes out of the nip reduces the time available for rewetting of the paper; but in no case is it possible to avoid such rewetting as occurs while the paper and felt are still held in contact under the progressively reducing pressure on the exit side of the nip.

As a practical matter provision must be made for removal of a portion of the water from the system consisting of paper and a compressible felt as the system moves through the nip of a pair of press rolls. In a plain press, having smooth imperforate rolls, this is accomplished by making the nip pressure high enough to compress both paper and felt substantially to saturation before they reach the point of maximum compression in the nip whereby water is forced to flow backwardly through the felt and to a lesser extent, through the paper, and away from the nip. The backflow of water has to run down the upwardly moving surface of the lower roll in order to be removed from the system. A freshly laid web of paper on a properly designed felt can withstand substantial pressure exerted perpendicularly to the surface thereof, as by squeezing between press rolls. However, it cannot withstand the high hydraulic drag forces which are developed as an incident to rapid reverse flow of water on the ingoing side of the nip, the resultant damage to the paper being known as "crushing". Therefore it has not been possible to operate plain presses at high speeds except at nip pressure so low as to result in very little dewatering of the web in each press. The high nip pressure can only be used at low speeds which are inconsistent with modern papermaking equipment.

To achive better dewatering at higher speeds without crushing the paper circumferential grooves or spaced blind holes have been formed in the surface of the lower press roll to receive and carry forward a portion of the water expressed from the system in the nip. Such water is permitted to flow from or is dislodged from the grooves or openings at a point remote from the nip. In still other instances suction presses are used in which the lower press roll comprises a perforated shell revolving over a stationary suction box located in the region of the nip. Most of the water squeezed from the saturated system of paper and felt is induced to flow into the perforation in the shell. While a small portion of such water moves into the suction box from which it may be removed through suction lines the major portion remains in the perforations from which some of it is eventually thrown by centrifugal force.

When ordinary compressible felts are used in presses having blind holes or grooves in the roll surface or in suction presses, the amount of nip pressure, and thus the amount of water removed from the paper, is limited by factors which usually outweigh the capability of the paper to withstand nip pressure as such. In any such press there is a tendency for the water to flow within the felt toward the grooves, holes or perforations and not toward the unbroken roll surfaces therebetween. This sets up an uneven pattern of flow through the felt which will extend into the body of the paper when the rate of flow is increased beyond a certain point. Uneven application of pressure and uneven dewatering of the paper cause objectionable local changes in appearance of the paper, generally referred to as "shell marks". In suction presses, the requirement that the lower roll be constructed as a perforated hollow shell having much less structural strength than a solid or imperforate roll places a severe limitation upon the amount of mechanical pressure which may be exerted at the nip between such a shell and the upper roll.

Another factor which has limited the amount of nip pressure which can be effectively used in any or all of the types of presses discussed above is the behaviour of the ordinary compressibl e felt under compression. The thickness and density of such a felt is dictated by several characteristics including among others, strength, dimensional stability, wearing quality, surface finish and the like. When such a felt is compressed, as in a press, the density throughout its thickness is increased, that is, its void volume is reduced, and resistance to flow of water therethrough is correspondingly increased. In high speed presses this increase in resistance occurs very suddenly just at the time that water must flow through the felt. Accordingly, very high hydraulic pressures can be developed in localized areas with danger of disruption of the paper or of the felt itself.

In accordance with the present invention there is provided a papermakers' felt for supporting a wet web in a papermaking machine during the passage of said web through the nip of a pair of press rolls for removing water from the web, comprising an endless belt having a base layer and a web-contacting facing layer united in face-to-face relationship with said base layer, said base layer being permeable to water and relatively incompressible in that it maintains under mechanical loading of 100 pounds per square inch at least about 60%, and preferably from about 94% to about 74%, of its unloaded thickness, said facing layer being permeable to water and relatively compressible in that it maintains under the same loading a thickness

not substantially greater than about 50% of its unloaded thickness, said base layer comprising a material having passage-ways of relatively large size which provide within said base layer a void volume for the reception of water expressed from said web and from said facing layer under the pressure exerted at the nip of said press rolls, and said facing layer having passageways of relatively small size which provide within said facing layer a void volume from which water is expressed (squeezed) under said pressure.

An illustrative form of felt embodying the present invention may comprise a woven base fabric which, because of fiber content, yarn construction, fabric construction, treatment before or after weaving or by combination of such factors, is or has been made substantially incompressible under the mechanical pressures which are to be encountered in the use of the felt. To such base fabric there is mechanically bonded as by needling or by the use of adhesive, a layer of relatively resilient material such as a fibrous batt or felted body which is compressible under the pressure encountered in use. A press felt of the illustrative construction may comprise a woven base fabric having substantial thickness and a compressible layer which may be relatively thinner than an ordinary compressible felt. The base fabric not only will afford requisite strength, stability and wearing characteristics, but also will afford a large void volume made up of spaces between yarns, plus, in some cases, spaces between the fibers or filaments in the yarn, which will remain substantially unreduced under the pressures encountered in the press. Thus, although the void volume of the compressible layer will be reduced when the felt goes through the nip of a press, the total void volume of the felt will be reduced much less than would be the case if the felt were compressible throughout its thickness. The void volume thus preserved may be utilized to receive water squeezed from the paper and the compressible layer. The dimensions of the spaces between adjacent yarns in the incompressible base fabric, which account for a substantial precentage of the total void volume of the base fabric, may be established as desired by the selection of yarn diameter and yarn count. Thus the spaces may be made relatively small so as to tend to retain water as a result of surface tension, or they may be made relatively large so as readily to permit the passage of water through the base fabric in a direction away from the compressible layer and the paper. Press felts having base fabrics tending to retain water are particularly useful in connection with plain presses in that the water retained in the base fabric will be carried forwardly away from the nip and may be removed from the felt after separation of the paper from the felt. Felts having base fabrics with little tendency to retain water are particularly useful in connection with suction presses or presses in which one of the rolls is provided with openings or grooves. In such felts water squeezed from the paper and the compressible layer of the felt will pass readily through the substantially unaffected openings in the base fabric for removal by the suction equipment or other water removing provisions in such presses. Also, felts having base fabrics, with little tendency to retain water may be used with great effectiveness in plain presses in which the unbroken surface of the press roll which engages the base fabric is constructed or treated so as to have a greater affinity for water than the base fabric. In such instances the water received by the openings in the base fabric in the nip of the press will adhere to and be carried away from the felt by the roll surface upon separation of the felt from the roll. The water thereafter may be doctored off the roll.

Press felts designed in accordance with the present invention for use in plain presses make it possible to secure equivalent or superior dewatering of paper by the use of plain presses under conditions in which it heretofore has been necessary to use suction presses. The removal of the substantial amount of water which is carried away from the nip of a plain press within the voids provided in the incompressible layer of such felts is accomplished without danger of crushing the paper. The void volume of the incompressible layer can be made large enough to carry away an amount of water comparable with or greater than the amount of water removed by a suction press. Reduction of the danger of crushing and the ability to remove substantial quantities of water from the nip makes it possible to run plain presses at much higher rates of speed and at much higher nip pressures with felts of the present invention than has been possible with the compressible felts used in the past. Suction presses are expensive to install and maintain and frequently are very noisy in operation. Plain presses are much less expensive to install, are quiet, rugged and require very little maintenance. Therefore, a particular advantage of the present invention is that it extends the utility of plain presses into applications in which suction presses were previously required.

In order to reduce rewetting of the paper during the period of time that the paper remains in contact with press felts, made in accordance with the present invention, beyond the point at which nip pressure begins to fall off, the permeability of the compressible layer may be made substantially lower than is customary for compressible felts heretofore used. This is particularly true of press felts in which the compressible layer is relatively thin and which should be quite firm in any event, to prevent marking of the pattern of the incom-

pressible base fabric in the paper. The compressible layer thus can be made with very small voids which offer substantial resistance to the capillary flow of water and thus reduce the rate at which water may flow through the layer to the paper under conditions of reduced mechanical pressure. However, because of the relative thinness of the layer and the very high nip pressures that may be applied to felts made in accordance with this invention, the relatively low permeability thereof will not prevent the forced flow under nip pressure of substantial quantities of water from the paper through the compressible layer and to the voids provided in the base fabric. The tendency toward rewetting of the paper as mentioned above may also be reduced by making the compressible layer of water repellent material or by making the layer water repellent, as by chemical or other treatment of the layer or of the fibers or other material from which the layer is made. The water repellency of the layer will not prevent the flow of water through it under nip pressure, but will tend to impede backflow of water from the base fabric through the layer when nip pressure is reduced or removed.

The present invention will now be described in greater detail with reference to the accompanying drawings in which:

Figure 1 is an enlarged fragmentary diagrammatic vertical sectional view of a papermakers' felt made in accordance with the present invention and comprising two layers made of materials differing in compressibility;

Figure 2 is a diagrammatic view of a plain press in which a papermakers' felt embodying the present invention is illustrated along with various devices for removal of water from the felt; and

Figure 3 is an enlarged fragmentary diagrammatic vertical sectional view of a felt embodying the present invention showing the same in use between vertically stacked press rolls of one well known type.

Referring now to the drawings, there is illustrated in Figure 1 a papermakers felt designed especially for use in the press section of papermaking machines, which consists broadly of a base fabric 10 and a cushioning layer 12. The layers 10 and 12 are secured to one another, as will be described below, to form a laminated or duplex structure which is indicated generally by the reference numeral 14. For convenience, in the description herein the laminated structure 14 will sometimes be referred to as a "felt", and in this connection the word "felt" is used in the not necessarily accurate sense in which such word is generally used when referring to papermakers felts. It will be appreciated that papermakers felts are seldom if ever a non-woven felted structure but rather are customarily woven fabrics or combinations of woven and non-woven materials which are treated as by fulling, shrinking or needling to form relatively firm structures which have some resemblance to non-woven felts.

The base fabric 10 is illustrated herein as a woven fabric made up of interlaced warp yarns 16 and weft yarns 18, the material or materials from which the yarns are made and the construction of the yarns and the pattern of interlacing or weaving of the yarns as well as treatments of the materials or the yarns or the woven fabric all are so related as to produce a base fabric 10 which has a permeability significantly higher than that of conventional press felts and which is relatively incompressible under compressive stress applied in directions generally normal to the plane of the fabric. The surfacing layer 12 is made of a material or is so treated, or both, as to be relatively compressible under similar stresses and to have permeability in the order of that of conventional press felts. The composite felt 14 thus displays on one side the cushion and resilience of the compressible layer 12 and on the other the relative rigidity and open screen-like structure of the relatively incompressible base fabric 10. The felt 14 is designed for use with the web of paper in facewise contact with the exposed surface of the layer 12.

The layers 10 and 12 of the felt 14 preferably are permanently united in face to face contact by the use of techniques which are appropriate for the particular combination of materials utilized in the forming of the layers 10 and 12, respectively. For example, the layers may be secured together by an adhesive material which is compatible with and will form useful permanent bonding between the two layers 10 and 12. Also, for example, the layers 10 and 12 may be united by the well-known needling process in which the two layers are superimposed in desired final position and they are subjected to the action of a needling loom the needles of which will be effective to entangle certain of the fibers or other elements of one or both of the layers 10 and 12 with the other.

For use as a papermakers felt and particularly for use in the press section of a papermaking machine the felt 14 has the form of an endless belt which is devoid of seams or splicing or other types of join which would tend to produce in the area of the seam or splice a texture, porosity, compressibility or moisture absorbtivity which is different from that of the remainder of the area of the felt. Preferably therefore the felt 14 is formed with a base fabric 10 which is woven in tubular form in a loom of the type customarily utilized for the production of endless papermakers felts. The layer 12 may be made of woven and felted textile materials, but is preferably formed from a batt of suitable fibrous material which has been formed by carding, garnetting or other well-known procedures which are effective to orient a mass

of discrete fibers in substantially one direction, thereby to form a batt which is quite uniform in fiber distribution and orientation, as well as in thickness and density.

A tubular woven endless belt of base fabric 10 which is useful in connection with the present invention may be manufactured in the manner disclosed in Specification No. 827754. Such a fabric may be utilized in the condition as woven or it may be stabilized in accordance with the teaching of said Specification or in accordance with the teaching of Specification No. 949478. Fabrics of this type, whether treated or untreated for stabilization, are so constructed that the weft yarns which are supplied by one or more shuttles in the loom extend lengthwise of the endless belt while the warp yarns which are supplied from the warp beam of the loom run transversely of the length of the endless belt. It is preferable from the standpoint of dimensional stability, as well as from the standpoint of length of life of the fabric, that the weft yarns that is, the yarns laid by the shuttles, run in substantially uniform direction lengthwise of the belt, while the loom warp yarns assume curved shape to form knuckles at each yarn crossing as a result of the positioning of the warp yarns above and below the relatively straight weft yarns in the fabric. Abrasive wear upon the knuckles of the transversely extending loom warp yarn will progressively weaken these warp yarns, but this will have little, if any, effect upon the tensile strength of the fabric in the all important longitudinal direction, which is direction in which the fabric runs in the machine. Also, it is preferable to select for the weft yarns such materials or construction or both as to afford maximum tensile strength and resistance to stretch or deformation under the tensile loads to which the fabric will be subjected in use in a papermaking machine. On the other hand, the transversely extending warp yarns are preferably selected for resistance to abrasive wear.

In Figure 1, which is a transverse sectional view of the felt 14, it will be observed that the warp yarns 16 assume the curved shapes discussed above, while reference to Figure 3 will reveal that the weft yarns 18 lie substantially straight within the fabric. While, as indicated above, this particular feature of specification No. 827,754 is preferably incorporated into the present invention, it will be understood that this particular manner of weaving and of yarn selection is not necessarily critical in all forms of the present invention, since stability and wear resistance may be contributed by other factors which will be discussed hereinbelow. Also, while Figures 1 and 3 show a base fabric 10 which incorporates a plain weave, other types of weave, particularly satin weaves and crows foot weaves may be utilized with attendant advantages in particular instances. For example, a four-harness satin weave may be employed for the purpose of affording a relatively much smoother upper surface upon the base fabric 10 than is afforded by the illustrated plain weave.

The primary characteristic of the base fabric 10 for use in the present invention is its relative incompressibility as compared with the compressibility of the surfacing layer 12. Under a compressive stress in the order of magnitude and in the direction of the compressive stress exerted upon a press felt when passed between the press rolls of a paper making machine, the base fabric 10 will be relatively little decreased in thickness, while the surfacing layer 12 will be relatively greatly decreased in thickness. The decrease in thickness of the surface layer 12 ordinarily will result in the expression from said layer of water, which in turn has been expressed from a moist paper web, thereby depositing the water in or forcing the water through the voids in the base fabric 10. It will be understood that if the base fabric 10 were to be substantially as compressible as the surfacing layer 12, as is the case in the papermaker's felts presently in use, the volume of the voids in the base fabric 10 would be reduced under compressive loading, thereby restricting the amount of volume available for receiving water or impeding the flow of water which is expressed from the surfacing layer 12. The relative incompressibility of the base layer 10 in accordance with the present invention provides for the substantial preservation of the volume of voids as well as the substantial prevention of impedance to the flow of water. Felts made in connection with the present invention thereby afford substantial volume for the retention of water to be carried away from the system in certain press configurations or alternatively facilitate rapid and efficient withdrawal of water from the system by suction means or the like which are utilized in other press configurations. In either of these respects felts of the present invention afford substantial improvement over felts of the prior art which when compressed in presses of any configuration offer both reduced void volume and increased resistance to flow of water.

Referring now to Figure 2, a felt 14 made in accordance with the present invention is illustrated in connection with a press in a papermaking machine. It will be understood that papermaking machines ordinarily are provided with at least one such press and in most instances are provided with two or three or even a greater number of presses. The usual plurality of presses in a papermaking machine is arranged in a series whereby the first press is encountered by the paper at a time when the moisture content of the paper is relatively high. Assuming that a certain amount of

moisture will be removed from the paper by the first press, it will be apparent that the second and third presses, for example, will be called upon to operate upon the paper when the latter has progressively lower moisture contents. With this in mind the specific configurations of successive presses in a paper machine frequently differ in detail to take into account the lower moisture contents at which the paper enters successive presses. For the purposes of illustration of the present invention the felt 14 is shown in a press which may be assumed to be the first press, although it will be understood that felts embodying the present invention are intended to be used in any or all of the presses of a papermaking machine as may be desired.

Thus in Figure 2 the felt 14 is shown as progressing through an endless path defined by a guide roll 20, a pair of vertically stacked press rolls 22 and 24, guide rolls 26, 28, and 30, and a pair of squeeze rolls 32 and 34. A web of paper 36 is shown as being projected from a web carrier 38, only a portion of which is shown, which is guided around a roll 40. The web carrier 38 may be a felt in which event roll 40 will be a guide roll, or the web carrier 38 may be a Fourdrinier screen, in which event the roll 40 will be a couch roll or equivalent. The web of paper 36 is received upon the upper or outer surface of the felt 14 and as shown in Figure 2 the surfacing layer 12 of the felt 14 is arranged outermost of the endless path in order to receive the paper web 36. The paper web 36 travels with the felt 14 to the press rolls 22 and 24 and may be guided upwardly as shown in Figure 2 to remain in contact with the surface of the upper press roll 24 for at least a short distance beyond the nip of the press rolls 22, 24. Alternatively the felt 14 may be guided downwardly beyond the nip to follow the surface of the lower press roll 22 for at least a short distance, in which event the paper web 36 may leave the nip horizontally or at an upward angle as preferred. In any case it is preferred that the paper web 36 and the felt 14 be separated as quickly as possible after the passage thereof through the nip of the press rolls 22 and 24 to minimize rewetting of the paper.

After leaving the lower press roll 22 the felt 14 may be conducted through any one or more of several dewatering devices which serve to dislodge or extract water therefrom as it progresses through its return path in order to reduce the moisture content of successive areas thereof before such areas come into contact with successive portions of the paper web 36. Several dewatering devices have been illustrated in Figure 2 and while all of them might possibly be used in a single installation, the more normal procedure would be to use one or more of them on a selective basis, taking into account the particular design of the felt 14 as well as the particular press configuration.

As illustrated in Figure 2 the lower press roll 22 may be used as a felt dewatering device. When a felt 14 is used, which has a base fabric 10 through which water may readily flow, water expressed from the system of paper 36 and compressible layer 12 into the incompressible layer 10 will readily flow through the latter. When the press is a "plain" press the rolls 22 and 24 have smooth cylindrical surfaces which are imperforate and water deposited upon the surface of the lower press roll 22 will tend to adhere to the surface thereof to be carried downwardly and away from the felt 14. Water adhering to roll 22 may be doctored off the surface thereof by a blade or other suitable doctoring device 42. As indicated at 44 such water will be deposited in a receiver 46 from which it may flow or be withdrawn through a conduit 48. Preferably, the receiver 46 is provided with a wall or baffle 50, which is interposed between a major portion of the lower surface of the roll 22 and the underside of the felt 14. The baffle 50 will serve to reduce likelihood of water being flung from the surface of the roll 22 by centrifugal force with resulting redeposition upon the underside of the felt 14. The surface of the lower press roll 22 may be treated to have even greater affinity for water if so desired to enhance the dewatering effect of the lower roll 22 and doctor 42.

A second dewatering device shown in Figure 2 consists of one or more nozzles 52 (two are shown) arranged to direct a blast of compressed air or other gas which may or may not be heated above room temperature against the outer surface of the layer 12 of the felt 14.

The nozzles 52 may be circular in cross-section having circular orifices 54, in which event there may be two closely spaced rows of such nozzles extending transversely of the entire width of the felt 14. Alternatively the nozzles 52 may be elongated hollow structures having orifices 54 in the form of elongated slots extending throughout the width of the felt 14. In either event the air or other gas discharged from the nozzles will penetrate the compressible layer 12 and the incompressible layer 10 to dislodge water from both layers. The dislodged water may be received in receivers 56 from which it may flow or be withdrawn through conduits 58; if desired, suction may be applied to receivers 56 through conduits 58, with or without the use of air blast nozzles 52.

A third dewatering device is shown in Figure 2 consisting of the guide roll 28 which is of such relatively small diameter as to cause centrifugal throw-out of water from the felt 14. The diameter of the roll 28 is so related with the linear speed of travel of the felt 14 so as to achieve the desired degree of de-

watering. Preferably the roll 28 is so positioned that the compressible layer 12 of the felt 14 comes into engagement with the roll whereby the relatively open-weave base fabric 10 is outermost. In this manner water retained within the layer 10 as it approaches the roll 28 will be thrown out of the voids in the layer 10 as a result of the rapid change in direction of travel of the felt 14 as the felt passes around the roll 28.

A fourth dewatering device shown in Figure 2 consists of the squeeze rolls 32 and 34 which are pressed toward one another to apply pressure to the felt 14. While both of these rolls may have smooth imperforate surfaces and thus will act as ordinary wringer rolls it will be appreciated that more effective dewatering may be achieved by the use of a drilled suction roll for carrying away a portion of the water squeezed out of the compressible portion of the felt 14. Thus, the lower roll 34, as shown in the drawing, or the upper roll 32, if so desired, may consist of a hollow shell having a plurality of openings 60 extending through the shell. A stationary suction box 62 having sealing strips 64 and a suction pipe 66 is positioned within the shell of roll 34 to withdraw water through the openings 60 in the region of the nip between rolls 32 and 34. When the lower roll 34 is a drilled suction roll, as shown, the water which is expressed from the compressible layer 12 will enter the perforations in the roll 34. If the roll 32 is a suction roll the water squeezed out of layer 12 will be removed through the open weave of the layer 10.

The various dewatering devices described above in connection with Fig. 2 do not, themselves, constitute the invention for which protection is sought in this application. However, the use of any one or more of such devices or other equivalent devices with felts of the type herein disclosed constitutes a part of the present invention. Furthermore, the use of one or more dewatering devices selected for particular efficacy in combination with particular types or forms of felts constructed as taught herein, constitutes a part of the present invention.

From the foregoing portion of the present description it will be apparent that felts, made in accordance with the present invention afford, in various combinations, the removal of water from the nip of a pair of plain press rolls in the direction of movement of the felt and that one or more of the dewatering devices illustrated herein may be used to dispose of the water thus removed from the nip. Use of felts of the present invention is not limited, however, to combinations including plain press rolls and supplemental dewatering devices. Felts of appropriate design within the teachings of the present invention are also highly useful in connection with suction presses and when so used serve to obviate many of the difficulties and disappointing results heretofore achieved with suction presses. Thus, in Figure 3 there is illustrated a felt 14 consisting of a base fabric 10 and a cushioning layer 12 as described above supporting a wet web of paper 36 against the surface of the upper press roll 24. The upper press roll 24 is pressed downwardly with suitable force so as to compress the paper 36 and the compressible cushioning layer 12 as successive increments thereof pass through the nip. The lower press roll 122 comprises a hollow shell having a large number of perforations 123 extending radially therethrough. A suction box 125 is positioned within the lower press roll 122 and is provided with sealing lips 127 which engage the inner surface of the roll 122 whereby suction may be exerted through those perforations 123 which are located within the zone of the nip between rolls 24 and 122. A conduit 129 is connected with the suction box 125 and a suitable vacuum pump (not shown) to withdraw water and air from the box 125.

As illustrated in Figure 3 the paper web 36 and the compressible layer 12 of the felt 14 are both compressed as they pass through the nip between rolls 24 and 122. Such compression will be effective to reduce the volume of the compressed portion of the web and felt. When the amount of water in each increment of the paper web 36 is greater in volume than the volume of such increment when compressed in the nip the excess water will be squeezed from the web into the felt 14. It is assumed that the felt 14 is air dry when the paper making machine is first started up it may require several complete circuits of the endless path of the felt 14 before sufficient water is transferred to the felt 14 by successive increments of the wet paper web 36 for the felt 14, particularly the compressible layer 12 thereof, to become wet enough to start giving up water at the nip of the press rolls. When this condition of equilibrium is reached normal operation sets in wherein water is squeezed out of the paper web 36 and the compressible layer 12 of felt 14. In such normal operation the volume of water available for removal from an increment of the combined paper web and compressible layer 12 in the nip is greater than the total void volume thereof when under full compression. The void volume of the relatively incompressible layer 10 of the felt 14 is not reduced to a similar extent and, as will be apparent from Figure 3, the openings in the incompressible layer 10 remain relatively unclosed whereby water expressed from the paper 36 and layer 12 may flow freely through the layer 10 and into the suction holes 123 of the suction press roll 122. This is a particular feature of the present invention.

For use with a suction press as illustrated in Figure 3 a felt 14 made in accordance

with the present invention is preferably constructed with a relatively incompressible layer 10 which will readily release water under the influence of the suction roll 122. By controlling the characteristics of the layer 10 in accordance with the teachings herein the layer 10 may so readily release water in the nip of the suction press that no supplemental dewater devices such as those shown in Figure 2 may be required in connection with the manufacture of a wide variety of grades and weights of paper under a wide variety of conditions such as machine speed, moisture content, nip pressure and the like. However, a great change in one or more of such factors without changing to a different felt 14 may result in incomplete removal of the water in layer 10 at the suction nip, in which event the remainder of the water will be carried forward and out of the nip while still retained in the layer 10. In such cases one or more dewatering devices such as shown in Figure 1 may be used to remove more water from the layer 10 or from both layers 10 and 12 of the felt 14.

It will be appreciated that the felt 14 may be initially designed for use in a particular installation in which both a suction press such as shown in Figure 3 and one or more dewatering devices such as shown in Figure 2 are normally required. In any event, when a suction press is used the layer 10 need not have a void volume, when compressed, such as to accommodate all of the water squeezed from the paper 36 and compressible felt layer 12. Thus a relatively thin finely woven relatively incompressible fabric may be used as the layer 10 and because such a fabric will diffuse the flow of water and air therethrough and also will have relatively little tendency to mark its pattern on the paper, the compressible layer 12 may also be relatively thin. Even with such relatively thin layers 10 and 12 the felt 14 can be used with higher nip pressures and higher suction differential at the nip and at higher machine speeds than heretofore have been used with convention wet felts of much greater total thickness. This is because the problems of crushing, suction hole marking and felt or shadow marking of the paper are approached and solved by the present invention in manners which are consistent with one another rather than inconsistent as has been the case with conventional felts.

When felts in accordance with the present invention are used with presses having a blind drilled, etched or annularly grooved roll in contact with the felt the construction of the felts will follow generally the same principles as those designed for use in suction presses. That is, the relatively incompressible layer 10 will be designed to permit or promote the flow therethrough of water at a rate within the capacity of the holes, etchings or grooves. Also, if so desired the layer 10 may be designed to retain an appropriate amount of water in excess of the capacity of the water receiving means of the press roll and to carry such retained water forwardly through the nip for removal by one or more dewatering means such as shown in Figure 2.

As indicated above a particularly important feature of the present invention is its contribution in increasing the dewatering capacity of a so-called plain press, that is, a press using a pair of plain-surfaced press rolls. For such use the layer 10 should be so designed as to receive in the nip all of the water squeezed out of the paper 36 and compressible layer 12. Also, the layer 10 should retain and carry forward out of the nip as great a proportion as possible of the water it receives in the nip, less of course such quantity of water as may adhere to the surface of the lower press roll 22 (Figure 2). To this end the layer 10 is preferably so designed as to resist or slow down as much as possible the tendency for water to be reabsorbed by the expanding compressible layer 12. At the same time the layer 10 should not be so constructed as to retain the water so tenaciously as to make the removal thereof impractical by one or more of the dewatering devices shown in Figure 2. In this connection the air blast device 52, 56 and the suction wringer device 32, 34 are relatively more effective than the centrifugal device 28 and the first-named devices will effectively dewater felts having a layer 10 of high capillary attraction whereas the centrifugal device 28 is recommended for use only with materials having very little or no capillary attraction for water. On the other hand, relatively high capillary attraction is desirable for the layer 10 inasmuch as the fibrous compressible layer 12 inherently has a very high capillary attraction and will tend to reabsorb water very rapidly from a layer 10 which has a very low capillary attraction. Accordingly it some times is preferred to construct the relatively incompressible layer 10 from relatively fine, closely woven yarns to provide small inter-yarn openings and in some cases to apply surface treatments or the like to promote the affinity thereof for water. In such cases it will be recognized that one or more dewatering means of maximum efficiency is preferable over a single relatively inefficient dewatering means.

The problem just discussed can be minimized however, by proper design of the compressible layer 12 of the felts 14 provided herein. Thus, although the layer 12 is similar to a conventional papermakers wet felt in that it should be compressible to provide a cushioning effect and has to present a smooth surface characteristic of a batt of closely packed or felted fine fibers, and should readily receive the water squeezed out of the paper, the latter requirement does not mean that the

layer 12 must be a highly absorbent or hydrophillic structure as has been the case with many conventional felts. To the contrary, the layer 12 may be treated to make it quite water repellent under normal atmospheric and gravitational influences because it is only required in the present combination, to permit water to flow rapidly therethrough under the pressure and impact conditions which exist in the nip of a pair of press rolls operating at a high rate of speed. Thus, the tendency of the layer 12 to reabsorb water from the layer 10 on the exit side of the nip may be so reduced that, during the brief time that the paper 36 remains in contact with the layer 12 beyond the maximum pressure point of the nip, only a very little water will become available for reabsorption by the paper.

Reduction of the tendency toward reabsorption of water by the layer 12 from the layer 10 may also be achieved or enhanced by providing a barrier of restricted water permeability between the layers 10 and 12 of a felt 14 made in accordance with the present invention. For example in those forms of this invention wherein the layers 10 and 12 are laminated together by an adhesive, the amount or type of adhesive used may be varied, while still affording requisite security of lamination, to enhance or to minimize, as may be desired, the barrier effect of the adhesive. Also, for example, in those forms of the present invention in which the layer 12 is secured to the layer 10 by the familiar needling process, a water repellant or flow restricting material may be interposed between the layers before they are needled together. Thus, such a material, in liquid form, may be applied by a brush, roller or spray to the under side of the layer 12 or to the upper side of the layer 10, or both, before these layers are needled together.

Inasmuch as papermakers wet felts are more or less custom made for each particular installation the disclosure herein of specific examples, complete in all detail, is not regarded as the best way in which to enable those skilled in the art to make use of this invention. Instead, a very few typical constructions will be described and the various ways of controlling or establishing the particular characteristics which may be required in any particular installation will be described with relation to the effects which may be achieved with those typical fabrics. The principles thus disclosed will be readily applicable to felt constructions which differ in detail from the typical examples.

A typical felt 14 embodying the present invention may be constructed by using as the relatively incompressible base layer 10 a fabric of plain weave construction woven from nylon multifilament yarns. The yarns used for warp and weft may be identical and of relatively small diameter and firmly twisted. For example they may be three ply yarns having a total denier of about 420, each ply of 10 filaments and having a Z twist, three turns per inch and the yarn being plied by S twisting, twelve turns per inch. Such a fabric having 37 picks per inch and 49 ends per inch will be a relatively open mesh screen-like structure having a permeability substantially greater than that of conventional press felts. When such a fabric is subjected to a mechanical pressure normal to its surfaces of 100 pounds per square inch the thickness thereof will be reduced by only about 16% and there will be a proportionally small reduction in the total void volume thereof.

The compressible layer 12 of such typical felt 14 may consist of a batt of wool fibers made up of three layers each weighing about 8 ounces per square yard. Such a batt, needled three passes to unit the individual layers thereof and before use and partial plugging of its voids with paper fibers or solids, will have a compressibility of about 50% or more under pressure 100 pounds per square inch. When this batt is united with the particular base fabric 12 just described, the total thickness of the felt 14, before use, will be about 0.22 inches thick. The particular permeability and compressibility of a specific batt will depend largely upon the nature of the fibers in the batt and upon the extent to which it has been firmed by needling or other treatment. For example a batt which is passed only once through a needling loom will be more compressible and more permeable than one which has been given two or three passes through the same needling loom under the same conditions. The compressibility of such a batt will be affected, that is, usually somewhat reduced, by any chemical or other treatment to which it may be subjected to modify its water repellency characteristics or abrasion or fungus resistance as will be discussed hereinbelow. In a general sense layers 12 suitable for use in the present invention should have compressibility at least about comparable with that of conventional papermakers felts and greater compressibilities may be preferred. While compressibilities as low as about 45% are attainable it is preferable, for adequate cushioning, that layers 12 be used which have compressibilities, before use and partial plugging, of from not much less than about 50% up to about 70% in thickness under mechanical pressures in the order of those encountered in the press of a papermaking machine. In this latter regard the 100 pounds per square inch pressure selected for illustration herein is within the range of pressures normally encountered in such presses although in some instances the pressures encountered may be as much as 400 pounds per square inch.

A second typical papermakers wet felt 14 made in accordance with this invention may

have a compressible layer 12 of the same construction as that provided in the first example. The base fabric however may be woven from considerably larger yarns and with a considerably lower yarn count. For example such a base fabric may be a plain weave cotton and nylon mixture or blend with a yarn count of 11 picks per inch and 9 ends per inch. Such a fabric will have a compressibility of about 37% under the 100 pounds per square inch load described above. It will be recognized that the compressibility of such a base fabric is still substantially less than that of the fibrous batt which is applied thereto.

The compressibility of the base fabrics of either of the typical examples given above can be very substantially reduced by the employment of any one or more of the following techniques.

1. Modification of the weave pattern.
2. Modification of yarn count.
3. Variation in twist of yarns.
4. Selection of fiber.
5. Application of coating or impregnating materials with or without chemical reaction between such materials and the fiber of the yarn.

Modification of weave pattern affects compressibility in that the number of yarn crossings differ as between different weaves. Satin weaves tend to be more compressible than a plain weave and double fabric weaves, in which two sets of fillings are used for example, are even more compressible due to the availability of spaces between opposing filling yarns for deformation.

Modification of yarn count affects compressibility in that fabrics of higher count contain more fiber than fabrics of lower count. Thus, for the purposes of the present invention, the use of higher yarn counts with attendant decrease in compressibility, also provides smaller interyarn openings which exhibit a greater tendency to retain water. The base fabrics for felts to be used in plain presses are, as discussed above, preferably quite water retentive and also are preferably quite incompressible so that maximum void volume is preserved under nip pressure. For use in suction presses the base fabric layer 10 is not required to be retentive of water and also should present as smooth an upper surface as possible. Therefore, a satin weave or double satin weave fabric with the floats on the upper surface may be preferable to a plain weave even though the compressibility may be greater.

Variation in twist of yarns affects compressibility of the fabric in a manner which is directly related to the differing compressibility of the yarns themselves. Higher twists produce firmer yarns which in turn result in firmer, less compressible fabrics.

Selection of fiber affects compressibility of the fabric in that fibers with low moduli of tension and compression will produce a softer, more compressible fabric than fibers with high moduli, with other factors being kept constant. A polyamide such as nylon is an example of a fiber having the low modulus mentioned above while a polyester such as "Dacron" is an example of a fiber having a higher modulus. However, since nylon reacts readily with various treating materials fabrics woven from nylon yarns may be stiffened to a degree which exceeds the stiffness usually obtainable with untreated Dacron yarns. Therefore nylon is a particularly desirable fiber for the production of fabrics which are to have compressibility at a practical minimum.

Application of coating or impregnating materials can be employed to produce very marked reduction in compressibility of a fabric. For example the chemical treatment and setting techniques disclosed in specification No. 827,754 and in specification No. 949,478 are particularly effective not only to produce the stability and wear resistance contemplated in said specification but also to provide base fabrics of very low compressibility. Thus, the nylon multifilament base fabric described above in the first typical example and which has a compressibility of 16% at 100 pounds per square inch, untreated will have reduced compressibilities as follows, depending upon the type of treatment and quantity of applied chemical. When treated in accordance with a process disclosed in specification No. 827,754 with melamine formaldehyde and heat setting the fabric will have a compressibility of about 11%. When treated in accordance with the process described in specification No. 949,478, with a first stage of phenolic formaldehyde and a second stage comprising an aldehyde donor and with heat setting, the compressibility will be lowered to about 6%. Obviously the particular chemical treatment selected will depend on the particular fiber or fiber blend in the base fabric. For a base fabric similar to that described in the second typical example, which is made of nylon and cotton and has a compressibility, untreated, of 40% the following reductions in compressibility were obtained by treatment. Impregnation by a two-stage system with resorcinol formaldehyde plus melamine formaldehyde with a resin pick-up of 4% by weight (untreated fabric) resulted in a compressibility, after heat treatment of 24%. The same treatment but with a resin pick-up of 10% by weight resulted in a compressibility of 20%.

The treatments suggested herein for increasing water repellency may be effected by selection from the large number of commercially available treating materials whether they may be proprietary, secret formulations or may be known chemical compounds or mixtures. Preferably, the selected material should produce a so-called "durable" water re-

pellency and almost any of the well known surface active materials are useful for this purpose. It has been found that such treatments in general have very little effect upon the compressibility of the treated fabric or fiber batt whereby in a manner entirely consistent with the objective of the present invention the water repellency of the compressible layer 12 of a felt 14 may be greatly increased with but little, if any, reduction in compressibility.

The effect of compression under pressures in the order of those encountered in actual press operation can be better visualized in relation to the present invention by comparison of the void volume of typical fabrics under no compressive force and under such force. Thus a base fabric 10 similar to that described in the first example herein, when woven from nylon multifilament warp yarns having a weight of 4830 grains per 100 yards and multifilament weft yarns having a weight of 2890 grains per 100 yards with a warp count of 22.4 ends per inch and weft count of 28.6 picks per inch, will have a total volume, under no compression of 12 cubic feet per 3000 square feet of fabric. When compressed at 100 pounds per square inch this total volume is reduced, because the compressibility without special treatment as mentioned above, is about 16%, to about 10 cubic feet per 3000 square feet. The yarns used in this fabric were relatively coarse, being in the order of 0.03 inches in diameter and the weave was relatively open, that is the spacing between the yarns as woven was in the order of 0.01 inches. This fabric had a void volume, uncompressed, of 7 cubic feet per 3000 square feet. When it was compressed at 100 pounds per square inch, and was reduced in thickness by about 16% as noted above, the fabric still had a void volume only slightly less than 6 cubic feet per 3000 square feet. This means that the base fabric just described is capable of accommodating 6×62.4 or approximately 374 pounds of water per 3000 square feet. This quantity of water is approximately equal to the total amount of water present in 3000 square feet of paper at 90% moisture content, wet basis, which paper, bone dry, would weigh 40 pounds per 3000 square feet. It also is approximately equal to the total amount of water which must be removed from a paperboard web weighing 160 pounds per 3000 square feet bone dry, to reduce its moisture content from about 80% to about 63% wet basis. It is not intended to imply that such drastic reduction, in water content will be made in a single press, the figures just given are intended only to show that the void volume preserved in the base fabric under compression is adequate to handle any quantity of water which reasonably may be extracted from paper in a press.

Reducing the compressibility of the base fabric still further, as for example treating it with resin and heat setting it as described above, will assure the preservation of even greater percentages of the void volume under compression. It will be appreciated however, that resin treatment of a particular fabric will result in somewhat reduced original void volume due to the presence on and in the yarns of the resin. For example the untreated fabric described in the preceding paragraph was treated with resin in accordance with the process described in said specification No. 949,478 and after heat setting had an increase in weight, due to resin pick up, of about 12%. The treated fabric had a void volume, uncompressed, of 5.2 cubic feet per 3000 square feet. Since its compressibility, at 100 pounds per square inch was only 6%, the void volume under such compression was only reduced to about 4.9 cubic feet per 3000 square feet. From what has been said above it is apparent that the void volume thus preserved in the base fabric is more than adequate for the accommodation of such quantity of water as may be expected to be squeezed from a web of paper in a press.

With any of the base fabrics woven from synthetic multi-filament yarns which have been discussed above relatively compressible layer 12 may consist of the batt of fibrous material described in the first typical felt 14. Thus when about 24 ounces per square yard of wool fiber, for example, is needled to or is needled and thereafter adhesively secured to the base fabric the resulting felt 14 will have adequate cushioning characteristics to prevent marking of the base fabric weave in the paper, will have adequate water-accommodating void volume under compression and yet will be substantially thinner than a conventional wet felt of comparable tensile strength. The thinness of such felts 14 plus the fact that the base fabrics thereof are of relatively open weave makes it possible very readily to remove a substantial portion of the water retained in both layers 10 and 12 by any one or more of the dewatering devices illustrated in Figure 2. The dewatered felts of the present invention thus carry a far smaller amount of retained water to the incoming side of the press than is ordinarily carried by a conventional wet felt with the result that presses, whether plain or suction, may be so operated with the felts of the present invention as permanently to remove from the paper a greater portion of the water therein than it has been possible to remove in the past.

Base fabrics 10 of the type described above in the second typical construction usually are more compressible than the multi-filament base fabrics of the first typical construction but nevertheless are substantially less compressible than the conventional wet felts heretofore used, and the void volume as well as the nature of the voids preserved under compression is still quite adequate to accommodate the

amount of water which can be extracted from paper in a press. Also because of their somewhat greater compressibilities these base fabrics usually do not require that the cushioning layer 12 be as thick as is required for substantially less compressible base fabrics. For example with the cotton and nylon base fabric, resin treated to reduce its compressibility from say 40% to about 24% or less, as described above, the fibrous batt may consist of three layers of carded fiber as described above but in many cases only one or two layers may be required to impart sufficient cushioning and non-marking characteristics to the felt 14. The complete felt 14 may thus be held to a thickness of about 0.25 inches or less and it may be quite readily dewatered by devices such as those described herein.

It will be recognized that the void volume of the base fabric 10 may be somewhat reduced from the volume existing in the fabric before uniting the same with the compressive layer 12 as a result of insertion of some of the batt fibers of layer 12 into the base fabric 10 by the needling operation or as a result of the application of adhesive or barrier layer material to the base fabric 10 when a felt 14 is constructed in the various ways described above. In all such cases the resultant decrease in void volume is readily ascertainable and the effect thereof can be taken into account in the design of the fabric with assurance that the desired amount of void volume will be preserved under the compressive forces to which the finished felt is to be subjected in use.

As indicated above a preferred form of cushioning layer 12 is one made from a batt of suitably oriented fibers such as wool fibers or blends of wool and synthetic fibers such as polyamide fibers. Blends of wool fibers with other synthetic fibers including polyester fibers or acrylic fibers or batts composed wholly of one or more synthetic fibers may also be used providing the synthetic fibers have the requisite characteristic of retaining adequate resiliency and strength when wet with water. Other types of porous compressible materials having appropriate permeability may be used for forming the cushioning layer 12. Reference has been made herein to the relative permeability of the layers 10 and 12. While permeability to water is directly involved it is customary in this art to express permeability in terms of permeability to air as determined by standard Method No. D737-46, Air Permeability of Textiles, of the American Society for Testing and Materials. The material used for the compressible layer 12 should be such that when the layer 12 is attached to the layer 10, the layer 12 will have a permeability lying within the range of permeabilities of conventional press felts. Such range, determined as above is from about 18 to about 180 cubic feet of air per minute per square foot.

For use as the adhesive for securing any of the layers 10 and 12 disclosed herein together or for forming a barrier layer of desired restricted permeability between the layers 10 and 12 when so desired, an adhesive material should be selected which, as already indicated, is compatible with the material in both layers and which, when necessary, will develop a bond of requisite strength. To be compatible the adhesive material should not include any component or require any solvent, accelerator, hardener, heat treatment or the like which will harmfully affect the materials in the layers 10 and 12. Also, the adhesive when set or cured should be waterproof and reasonably flexible so as to remain effective during use of the felt 14 for its intended purpose. For example, to laminate a layer 12 consisting of a batt of wool fiber to a base layer 10 containing nylon, with or without cotton, an adhesive of the family of phenol blocked isocyanate resins may be used. A specifically useful adhesive of this type is made by Thiokol Corporation and identified as "Unithane No. 390T". This same material, or a similar one, also may be used to form a barrier layer, as described above, between a wool batt and nylon base when the batt and base are to be united by needling.

WHAT WE CLAIM IS:—

1. A papermaker's felt for supporting a wet web in a papermaking machine during the passage of said web through the nip of a pair of press rolls for removing water from the web, comprising an endless belt having a base layer and a web-contacting facing layer united in face-to-face relationship with said base layer, said base layer being permeable to water and relatively incompressible in that it maintains under mechanical loading of 100 pounds per square inch at least about 60%, and preferably from about 94% to about 74%, of its unloaded thickness, said facing layer being permeable to water and relatively compressible in that it maintains under the same loading a thickness not substantially greater than about 50% of its unloaded thickness, said base layer comprising a material having passageways of relatively large size which provide within said base layer a void volume for the reception of water expressed from said web and from said facing layer under the pressure exerted at the nip of said press rolls, and said facing layer having passageways of relatively small size which provide within said facing layer a void volume from which water is expressed (squeezed) under said pressure.

2. A papermaker's felt according to claim 1, wherein said base layer comprises a fabric woven in endless belt form from textile yarns.

3. A papermaker's felt according to claim 1 or 2, wherein said facing layer is a non-woven batt of fibrous material.

4. A papermaker's felt according to any one of claims 1 to 3, wherein said facing layer is united with said base layer by fibers which project from said facing layer into the material from which said base layer is made.

5. A papermaker's felt according to any one of claims 1 to 3, wherein said facing layer is adhesively bonded to said base layer.

6. A papermaker's felt according to claim 5, wherein said facing layer is a needled batt of fibrous material.

7. A papermaker's felt according to any one of the preceding claims, wherein the internal void volume of the base layer is at least equal under the compressive forces applied thereto in the nip of said press rolls to the volume of water expressed from said web and from said facing layer under the pressure exerted at the nip of said press rolls.

8. A papermaker's felt according to any one of the preceding claims, wherein the internal void volume of said base layer consists at least in part of spaces between yarns from which said base layer is woven and in which the spacing between said yarns is such as to promote retention of water in or the passage of water through said spaces.

9. A papermaker's felt according to any one of the preceding claims, wherein a barrier layer is interposed between said base layer and said facing layer, said barrier layer being sufficiently permeable to water to permit transfer of water under the pressure exerted at the nip of said press rolls from said facing layer to said base layer but said barrier layer being of such low permeability to water that substantially none of the water so transferred to said base layer will return to said facing layer after the nip pressure is relieved.

10. A papermaker's felt according to any one of the preceding claims, wherein the fabric forming said base layer is woven from yarns containing at least a substantial percentage of synthetic fiber.

11. A papermaker's felt according to claim 10, wherein the synthetic fiber comprises continuous multiple filaments.

12. A papermaker's felt according to claim 10 or 11, wherein said base fabric contains a stiffening material set therein to reduce the compressibility of said fabric whereby under said loading said fabric maintains from about 70% to about 95% of its unloaded thickness.

13. A method of removing water from a wet web in a papermaking machine, which comprises disposing the wet web on a papermaker's felt according to any one of the preceding claims, progressively moving the papermaker's felt through an endless path including a portion in which the felt and the web thereon are passed between a pair of press rolls; pressing the pair of press rolls together with the felt and web therebetween with pressure sufficient to squeeze water out of said web and into the felt for removal therefrom.

14. A method according to claim 13, wherein the pressure exerted by the pair of press rolls squeezes the water from the wet web into said facing layer while compressing said facing layer to a thickness not substantially greater than about 50% of the uncompressed thickness of said facing layer to force water to flow from said web and compressed facing layer into said base layer, but with a pressure insufficient to compress said base layer to a thickness less than about 60% of the uncompressed thickness of said base layer; carrying water from the nip between the pair of pressure rolls in the voids of said base layer; removing the web from the felt, and thereafter removing water from the felt in a portion of the endless path thereof in which the web is not disposed upon the felt.

15. A method according to claim 14, wherein the openings in said base layer are retentive of water and in which a substantial portion of the water retained in said openings is removed from said carrier by forcible expulsion.

16. A method according to claim 13, wherein one of the press rolls is adapted continuously to receive water from the openings in said base layer, the pressure exerted by the pair of press rolls being operative to squeeze the water from the wet web into said facing layer while compressing said facing layer to an extent sufficient to force water to flow from said web and said compressed facing layer into said base layer, but with a pressure insufficient to reduce the void volume of said relatively incompressible base layer to such an extent as to impede the flow of water through said base layer to said one press roll; and continuously removing water from said one press roll.

17. A method according to claim 13, wherein the pressure under which the press rolls are pressed together is sufficient to compress the base layer to a thickness not less than from about 75% to 94% of the uncompressed thickness of the base layer, and in which a preponderance of the water squeezed from the web and compressible layer into the openings in said base layer is carried away from the nip of the press rolls in the direction of travel of said carrier through said press rolls.

18. Apparatus for removing water from a wet web in the press section of a papermaking machine, which comprises a papermaker's felt according to any one of claims 1 to 12, means for supporting said felt for movement in an endless path; means for disposing a wet web on said facing layer; means for passing said felt and the web thereon between a pair of press rolls; and means for pressing said pair of press rolls together with the felt and the web therebetween with pressure sufficient to move water through the web and through said facing layer into said base layer; means for separating said web from said felt; and means

for progressively removing water from succeeding increments of said base layer prior to the return of said increments through said endless path into contact with succeeding increments of said wet web.

19. A papermaker's wet felt substantially as hereinbefore described with reference to the accompanying drawings.

20. A method of removing water from a wet web in a papermaking machine substantially as hereinbefore described with reference to the accompanying drawings.

21. Apparatus for removing water from a wet web in the press section of a papermaking machine, substantially as hereinbefore described with reference to the accompanying drawings.

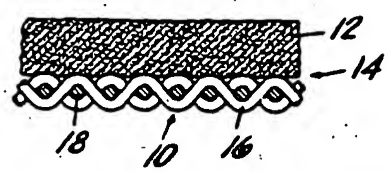
STEVENS, LANGNER, PARRY & ROLLINSON,
Chartered Patent Agents,
Agents for the Applicants.

Leamington Spa: Printed for Her Majesty's Stationery Office by the Courier Press.—1967.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obta

1059983 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG.1.



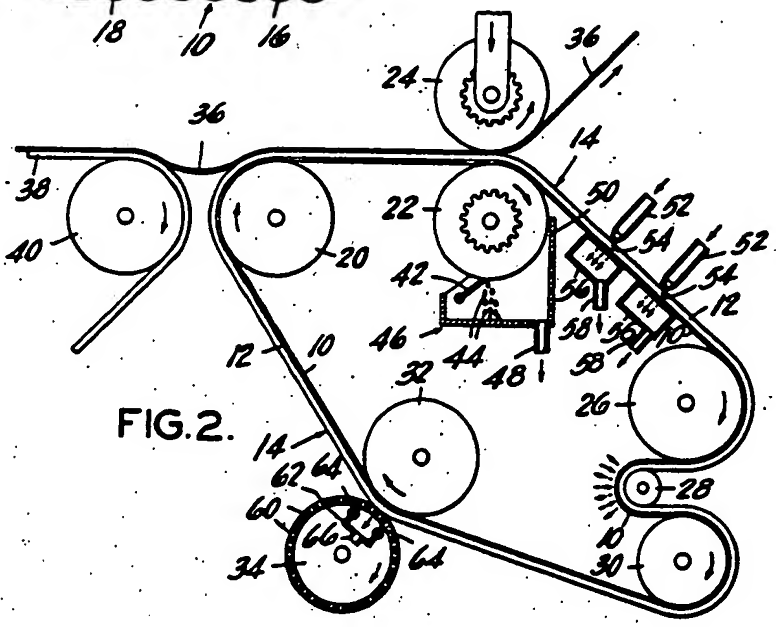


FIG.2.

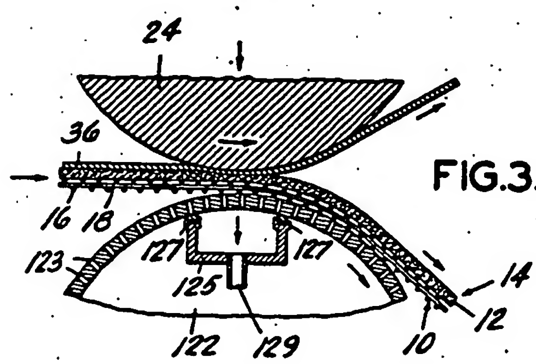


FIG.3.

THIS PAGE BLANK (USPTO)